PAWNEE COUNTY: Table Rock, May, 1896, *J. E. Shue.*

LANCASTER COUNTY: Lincoln, June 3, 1890, no. 6128, *H. J. Webber,* from Lucena Hardin; Lincoln, May, 1895, rich, moist woods, *E. B. Robinson;* another specimen by Fred C. Cooley without further data.

UNIVERSITY OF NEBRASKA, LINCOLN.

(To be continued)

The Soil Reactions of Certain Rock Ferns—I

EDGAR T. WHERRY

Judging from the literature, the ferns which grow on rocks would appear to be, on the whole, markedly sensitive to the chemical features of their soils. Their distribution is of course controlled to some extent by physical factors, such as climate, porosity of soil, availability of moisture, etc.; yet in many instances a given species has been observed to grow in soils of widely varying physical character, but consistently associated with a particular type of rock, and accordingly more or less uniform in chemical composition. Again, soils of like physical properties but dissimilar chemical nature often occur in such proximity that spores of the various ferns can not fail to have fallen into both kinds, yet flourishing plants have developed in but one of them.

It is commonly recognized that certain species of rock ferns grow by preference upon limestone and similar rocks, and are accordingly to be classed as calcareous soil plants. Other species, however, appear to avoid calcareous rocks quite definitely, and are presumably to be classed as acid soil plants. In the course of geological field trips and vacation outings for several years past the writer has been collecting information upon these

relationships. The first plan tried was to carry samples from the field to the laboratory, and there determine the percentage of calcium oxide (lime) present, both the total amount, and the soluble portion; and a brief account of some results thus obtained has been published.[1] Subsequently it has proved possible to work out a method for measuring, in the field, the soil reaction (acidity or alkalinity);[2] and as this is much simpler, as well as more instructive, than the determination of lime, an extensive series of such observations has been made, which it is the purpose of this paper to record.

The writer's field work on rock ferns has extended from Vermont and New Hampshire on the north to West Virginia and Virginia on the south, and all of the common species, as well as a few of the rarer ones, occurring within these limits have been studied. The results obtained are presented in table I, and subsequently discussed in detail. The correctness of previous classifications has been confirmed in most cases, but considerable new data have been obtained on many species. As pointed out in the above cited paper on rock ferns, it is the soil rather than the rock which affects the growth of plants; acid humus sometimes coats limestone ledges to such a thickness that species not normally favoring calcareous soils flourish there; and on the other hand, while the soils over sandstone, schist, granite, etc., are usually more or less acid in reaction, alkaline (calcareous) soils may accumulate on these rocks through the decomposition of vegetable debris, and typical calcareous soil species thrive there. Accordingly, actual tests have been made of the soils at the roots of the plants investigated. It is probable that further work will result in extending somewhat the ranges of reaction here recorded, although it seems unlikely that the classification of

[1]American Fern Journal, 7, 110–112, 1917.
[2]To be published in Journ. Wash. Acad. Sci., April, 1920.

many of the species will be changed. It is hoped, in particular, that species which the writer has been unable to study fully will be worked up by others.

TABLE I. CLASSIFICATION OF ROCK FERNS ON THE BASIS OF SOIL REACTION

Name	No. of tests	Soil Reactions									Class
		Mediacid		Subacid		Minimacid		Minimalk.		Subalkaline.	
						Circumneutral					
		300+	100	30+	10	3+	1	3+	10	30+	
Cheilanthes lanosa	15	–	x	X	**X**	x	x	–	–	–	A
tomentosa	(2)	–	–	(x)	–	(x)	–	–	–	–	A
Pellaea atropurpurea	30	–	–	x	X	X	**X**	X	X	X	C
glabella	5	–	–	–	–	–	**X**	x	x	–	C
Cryptogramma Stelleri	15	–	–	–	–	x	**X**	X	X	–	C
Phyllitis Scolopendrium	(2)	–	–	–	–	–	(x)	–	–	–	C
Camptosorus rhizophyllus	50	–	–	x	X	X	**X**	X	X	X	C
Asplenium pinnatifidum	20	X	**X**	X	x	–	–	–	–	–	A
ebenoides	15(1)	–	–	x	**X**	x	x	x	x	x	C
platyneuron	50	–	x	X	X	X	X	X	X	x	C
resiliens	15	–	–	–	–	x	**X**	X	X	X	C
Trichomanes	30	–	–	x	X	X	X	X	X	X	C
viride	(2)	–	–	–	–	(x)	(x)	–	–	–	C
Bradleyi	5(3)	X	**X**	X	x	–	–	–	–	–	A
montanum	20	X	**X**	X	x	–	–	–	–	–	A
Ruta-muraria	15	–	–	–	–	x	**X**	X	X	X	C
Polypodium vulgare	50	–	x	X	X	X	X	X	X	x	C
polypodioides	15	**X**	X	X	X	x	x	–	–	–	A
Woodsia glabella	15	–	–	–	–	x	**X**	X	X	X	C
alpina	5	–	–	–	–	x	x	–	–	–	C
Ilvensis	25	–	x	X	**X**	x	–	–	–	–	A
obtusa	30	–	x	X	X	X	X	X	X	x	C
Filix bulbifera	30	–	–	x	X	X	**X**	X	X	x	C
fragilis	30	–	x	X	X	X	X	X	X	x	C
Dryopteris fragrans	(2)	–	–	–	(x)	–	–	–	–	–	C

Totals: Acid soil plants, 7; calcareous soil plants, 18; sum, 25.

EXPLANATION OF TABLE I

The names used are those accepted by most present-day writers; important synonyms are given in the subsequent discussion. The number of tests made on each

species is recorded, and, as about three tests have customarily been made at each locality, the number of localities represented is approximately ⅓ of the number of tests. Tests made on soil adhering to the roots of herbarium specimens, which seemed desirable in a few instances to supplement field data, are distinguished by parentheses.

The terms used for the soil reactions are those recently proposed;[3] the numbers are "specific acidities" and "specific alkalinities," and represent the amounts of acid or of alkaline constituents (ions) present, with reference to pure water as a unit. Thus the number 300 on the acid side means that the corresponding soil contains that many times as much acid as water contains, and so on. All reactions of soils in which the various species have been observed to grow are marked with a letter *x*, in lower case for rarely observed values, capitals for frequently observed ones, and bold face letters for what may be termed optimum values, that is those shown by the most luxuriant and flourishing plants.

The majority of the species tabulated clearly favor reactions lying toward one side of the table or the other, and it is convenient to have some way of classifying them on this basis. Those the dominant reactions of which lie toward the left hand side may be termed "acid soil plants." It should be noted that the degree of acidity represented by habitats supporting these ferns is for the most part less than that of the sphagnum bogs and sandy barrens where so-called "oxylophytes" grow, so the latter term is not desirable for application here. It is also noteworthy that the acid soil species are dominantly southern in distribution. This class is designated by an *A*, for acid, in the last column of the table.

[3]Journ. Wash. Acad. Sci. 9, 305–309, 1919.

The complementary term "alkaline soil plants" is unsuitable for those showing dominant reactions toward the right hand side of the table, since the degree of alkalinity represented is at most but slight, and moreover no species of this class has been found which will not grow also in neutral and even slightly acid soils. The evidence indicates that the important factor in the case of plants avoiding the most acid soils is the relative abundance of calcium compounds, and accordingly "calcareous soil plants" will be used. The terms "calciphile" (lime lover) and "calcicole" (lime grower) are often applied to this class of plants. Since plants may grow in calcareous habitats for various other reasons than "love of lime" the latter term is the preferable one; but neither is really necessary. This class is marked in the table by a *C*, for calcareous.

It is evident from the table that no sharp line can be drawn between the two classes, as marked overlapping occurs in the central columns, especially in those of specific acidity 30, 10, and 3. Laboratory tests for calcium compounds have shown these to be present in practically all the soils concerned, their amount and especially their solubility diminishing markedly as the reactions approach mediacidity. By no means all species showing calcium compounds in their soils are calcareous soil plants; for when the specific acidity exceeds about 30 the physiological effect of the acid appears to predominate over that of the calcium; and although when the specific acidity is 10 or below, the effect of the calcium is dominant, some acid soil plants can still thrive even at the neutral point. In soils termed minimacid, plants of both classes may flourish side by side; but if enough occurrences of each species can be studied, the dominant reaction is always found to lie definitely toward one side or the other, and the plant can be assigned to the corresponding class.

FEATURES OF INDIVIDUAL SPECIES

Cheilanthes lanosa (vestita) is recorded in the literature as growing on sandstone, shale, schist, and trap rocks, and the writer has found it on the first three of these in Maryland, Virginia, and West Virginia. In these occurrences the soils have proved to be dominantly subacid to minimacid in reaction. In what appears to be the only recorded occurrence of this fern in a limestone region, that at Natural Bridge station, Virginia, it grows in clayey soil on a steep bank; and tests of this soil, for a specimen of which the writer is indebted to Mr. John P. Young. of Washington, D. C., have shown it to be neutral, any free calcium carbonate which may have been present having been leached out by the rain. This fern is therefore regarded as an acid soil plant showing a considerable degree of tolerance for calcium compounds.

It seemed a matter of interest to ascertain if other species of the above genus showed similar soil requirements, but no opportunity to study any others in the field presented itself. Accordingly tests were made on the soil adhering to the roots of specimens of *Cheilanthes tomentosa* in the U. S. National Herbarium, for which privilege—as well as for other valuable assistance in the preparation of this paper—the writer is indebted to Mr. William R. Maxon. In specimens from Paint Rock, North Carolina, where the rock is presumably, as usual for this fern, sandstone, the reaction proved to be subacid. In one from Natural Bridge Station, the locality referred to in the preceding paragraph—the reaction was low minimacid. This species is therefore also classed provisionally as an acid soil plant tolerant of calcium.

Pellaea atropurpurea, as observed in Pennsylvania and adjoining states, is found not only on limestone, but also on apparently noncalcareous sandstone, schist, shale,

etc. The literature shows similar relations to exist in other regions. Tests have shown circumneutral reactions to be present in most cases, however, and in exceptional ones where the soil is low in calcium compounds and subacid in reaction, the plant is stunted and plainly not thriving. *Pellaea glabella*, which is recorded in the literature only on limestone, has been studied at two localities near Allentown, Pennsylvania, to which the writer was kindly guided by Mr. Harold W. Pretz. The soil in both places being made up of dolomitic limestone fragments, the reactions naturally proved to be more or less alkaline. Both species of *Pellaea* are thus to be regarded as typical calcareous soil plants, with, in the former case, a moderate tolerance for acid reactions.

Cryptogramma Stelleri (*Pellaea gracilis*) has been recorded most frequently on limestone, but also occasionally on sandstone, slate, and gneiss rocks. In Vermont it was found to be definitely limited to calcareous gneiss, the soils being more or less alkaline; but at Lincoln Falls, Sullivan County, Pennsylvania, a locality brought to the writer's attention by Dr. Everett G. Logue, of Williamsport, it grows in wet crumbly red sandstone. Such rocks sometimes yield strongly acid soils, but in this case tests of the soil into which the fern's roots extended showed the reaction to be neutral or at most slightly acid. The usual classification of this species as a calcareous soil plant practically intolerant of acid is therefore believed to be correct.

The writer has not had the opportunity to study *Phyllitis Scolopendrium* (*Scolopendrium vulgare*) in the field, but its soil reaction seemed to be of so much interest that tests were made on the soils of herbarium specimens, kindly furnished by Mr. Maxon. As the latter has pointed out in describing the distribution of this fern in America,[4] it grows in Tennessee in a stiff clay, forming a

[4]Fernwort Papers, 30–46, 1900.

striking contrast to its soil at certain other stations, which is a black, friable leafmold. Both the clay from South Pittsburg, Tennessee and the leafmold from Jamesville, New York, yielded on testing practically neutral reactions, indicating the correctness of the usual classification of this fern as a calcareous soil plant. Although its distribution is of course largely controlled by climatic conditions, it is noteworthy that the results show it to grow in soils of divergent physical but uniform chemical character.

Camptosorus rhizophyllus (*Asplenium rhizophyllum*) has been found throughout Pennsylvania and adjoining states to be most frequent and luxuriant in circumneutral soils, although as noted in many places in the literature and emphasized in the writer's previous paper, the adjacent rock may vary widely. In occasional instances in which the soil was found to be subacid in reaction and low in calcium compounds the plant is, as a rule, stunted and weak-looking. Its usual classification as a calcareous soil plant may thus be accepted, although it is evidently fairly tolerant of acidity. It is interesting to compare with *Camptosorus* the related fern *Asplenium pinnatifidum*. The latter grows usually on sandstone, shale, schist, etc., and has apparently never been definitely reported on limestone or other calcareous rocks. A number of tests, made in Pennsylvania, Maryland, and Virginia, have shown its soils to contain some calcium compounds, but to be decidely acid in reaction. It is therefore to be classed as a typical acid soil plant, only slightly tolerant of calcium. The relations between these two ferns will be further discussed later on.

WASHINGTON, D. C.

(To be continued.)